STABRO LABORATORIES

MAINTENANCE INFORMATION FOR THE

DIGITAL MULTIMETER NO. 50200/50220

ENERGY CONCEPTS, INC. ECi

INTRODUCTION

This manual provides maintenance information for the Energy Concepts Digital Multimeter, Model No. 50200. Included are circuit board information, the various adjustments required, parts lists, schematic diagram, and other maintenance and troubleshooting information. Operational information for the Digital Multimeter is also included in book number 50209 (Operation Information for the Digital Multimeter).

Each new multimeter was inspected carefully, adjusted accurately, and tested thoroughly before shipment from the factory. As soon as you receive your Digital Multimeter, inspect the shipping carton and the equipment for damage. Any visible damage should be reported to the local carrier for repair or replacement. If the meter does not function properly, or if there is some question about how it should operate, contact the Energy Concepts Service Center.

This instrument is backed by more than sixty years of experience in design and manufacturing of educational and practical training equipment. Each unit is designed with a maximum degree of dependability, accuracy, and durability. New products are being designed constantly to meet the needs of both education and the service industries. We welcome comments that you may have about our products or test equipment.

It is both a privilege and a pleasure to continue serving you.

R. E. Gibbons,
President, Energy Concepts, Inc.

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SPECIFICATIONS*

DIGITAL MULTIMETER No. 50200/50220

DC VOLTAGE:
Ranges: 0-200 mV, 0-2 V, 0-20 V, 0-200 V, 0-1 kV
Accuracy: (±1 digit) ±.5%
Resolution: 100 μV low range
Input Impedance: 10 megohms on all ranges
Response Time: 1 msec

AC VOLTAGE:
Ranges: 0-200 mV, 0-2 V, 0-20 V, 0-200 V, 1 kV
Accuracy: (±1 digit) ±1.5%
Resolution: 100 μV low range
Input Impedance: 10 megohms on all ranges
Response Time: 10 msec

DC CURRENT:
Ranges: 0-20 μA, 0-200 μA, 0-20 mA, 0-200 mA, 0-2 amps
Accuracy: (±1 digit) ±1.5%
Resolution: 100 μA low range

AC CURRENT:
Ranges: 0-20 μA, 0-200 μA, 0-2 mA, 0-200 mA, 0-2 amps
Accuracy: (±1 digit) ±1.5%

OHMS:
Ranges: 0-200 ohms, 0-2K, 0-20K, 0-200K, 0-2M, 0-20M
Accuracy: (±1 digit) ±1% of full scale
Resolution: .1 ohm low range
Response Time: All Low ohm ranges except 2 MΩ range, and all ohms ranges, except 20 MΩ range, 1 second.
Ohms function current: 10 mA maximum

LOW POWER OHMS:
Ranges: 0-200 ohms, 0-2K, 0-20K, 0-200K, 0-2M
Accuracy: (±1 digit) ±1% of full scale
Resolution: .1 ohm low range

DISPLAY:
Numerals: 3½ digit, 7-segment LED, ½ in. high
Automatic: polarity, decimal, zero, and overrange indication

PROTECTION:
All electronic components and display are overload protected. A flashing LED overload indicator protects current and ohms functions circuit breaker. Transformer primary: ¼ amp fuse

POWER REQUIREMENTS:
Line Voltage: 120/240 VAC @ 50/60 Hz

*SPECIFICATIONS AND DESCRIPTIONS SUBJECT TO CHANGE WITHOUT NOTICE.

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SCHEMATIC

Additional information is included in the book Operation Information for the Digital Multimeter (Book No. 50209). Included in that book are operating information, operating procedures, and practical applications.

MAINTENANCE INFORMATION

GENERAL

The Energy Concepts Digital Multimeter is a precision instrument. It will provide you with years of trouble-free operation when used and maintained properly. The chassis parts and circuit board components are easily accessible when service is required. Parts and components are easily identified for convenience in troubleshooting.

NOTE

TROUBLESHOOTING, COMPONENT REPLACEMENT, AND CALIBRATION OF THIS INSTRUMENT SHOULD BE PERFORMED ONLY BY AUTHORIZED, QUALIFIED SERVICE PERSONNEL.

CASE REMOVAL

1. Disconnect the AC power cable from the AC source. Remove all test leads from the front panel.

2. Use a 9/64 in. Allen wrench to remove the four Allen-head screws from the end caps.

3. Lay the end caps and screws to one side. Remove the entire unit from the case by sliding it forward. It will usually be necessary to lift the front panel slightly so the unit clears the bottom ledge of the case.

CIRCUIT BOARD COMPONENT IDENTIFICATION

Figure 1 shows the electrical components mounted on the top of the Digital Multimeter circuit board. This diagram will aid in locating and identifying the various mounted components. The foil on the bottom of the circuit board is also shown (superimposed) to aid in visualizing the electrical connections.

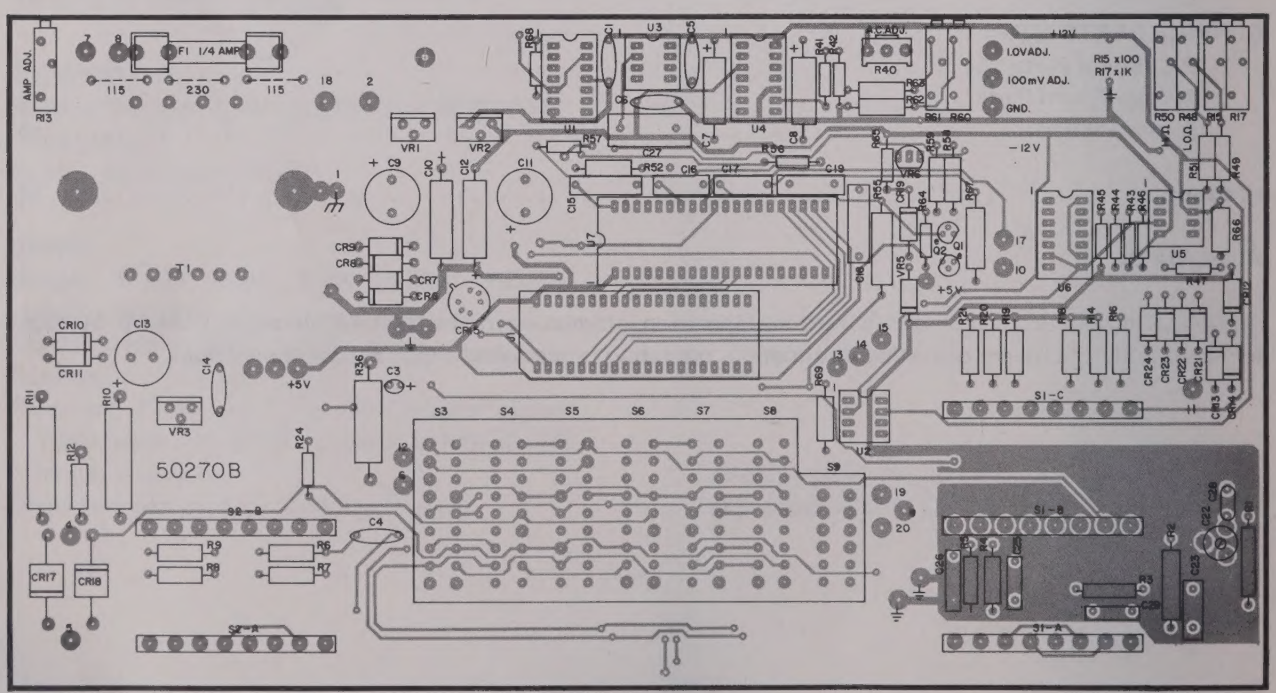

FIGURE 1A, Circuit Board Viewed From Component Side

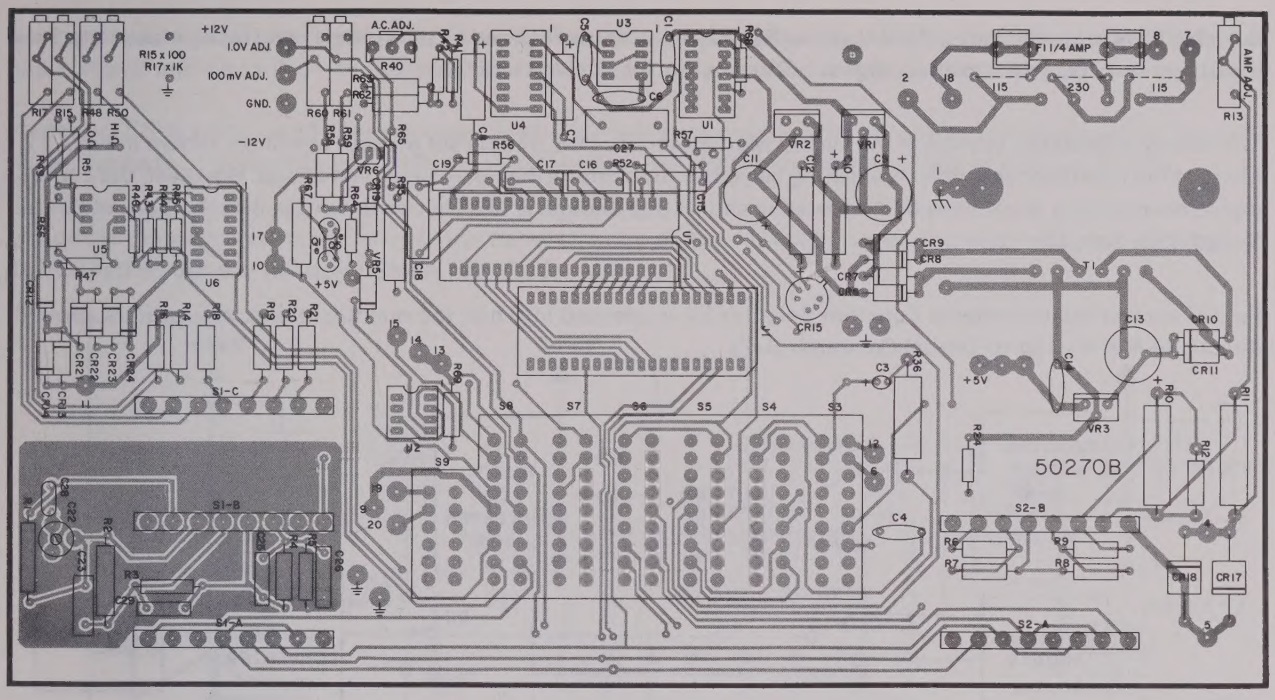

FIGURE 1B, Xray View of Circuit Board From Bottom Side

INTERNAL FUSE

The Digital Multimeter is equipped with an internal line-protection fuse. This fuse is rated at ¼ ampere. The fuse is located on top of the circuit board in the left, rear section. It protects the multimeter in the event of transformer failure or severe line voltage variations.

CIRCUIT DESCRIPTION

Figure 2 is a simplified functional diagram of the Digital Multimeter. It is included to show the "signal paths" used when measuring voltage, current, and resistance. A complete schematic diagram is given in the back of this Maintenance Manual. The component numbers given in Figure 2 are correlated to the schematic diagram.

ANALOG-TO-DIGITAL CONVERTER AND DISPLAY

The Analog-to-Digital Converter (U7) is a high performance, low power, 3½ digit Integrated Circuit. It has all the necessary circuitry to perform an analog-to-digital conversion. It drives the 3½ digit display directly without further decoding.

All of the preconditioned signals (maximum of 200 mV) are fed to the Analog-to-Digital Converter (U7). In this way the value of the electrical quantity being measured is shown by the display. Polarity is indicated for DCV and DCA functions. When an overrange condition occurs for DCV or DCA, the display blanks out, except for the +1 indication. For overranges of the ACV, ACA, or OHMS functions, only the 1 is indicated. Decimal points are controlled by S1, Sec. A and S2, Sec. A.

MEASURING DC VOLTAGE AND CURRENT

The voltage measuring section of the multimeter is shown across the top of Figure 2. For DC voltage measurements, the voltages go from the Resistive Ladder, through Function Selector S3C through voltage range switch S1, through S3F to the Analog-to-Digital Converter (U7). The Resistive Ladder consists of R1 - R5. It works with the Volts Range Switch (S1) and conditions the incoming signal to a maximum value of 200 mV. The wiper of

switch S1 B is set to the pick-off point on the Resistive Ladder as required by the voltage level being measured. This maintains the 200 mV maximum signal necessary for the Display Indicator.

The current measuring section of the Digital Multimeter uses the middle set of input terminals shown in Figure 2. Much of the input processing for measuring current is the same as that for measuring voltage. However, the current inputs are changed to voltages by the resistive shunts (R6 through R13). These are switched by the Current Range Switch (S2, Sec. B).

For DC current measurements Function Selector S4 is pressed in. Then the quantity being measured is applied directly to the Analog-to-Digital Converter (U7).

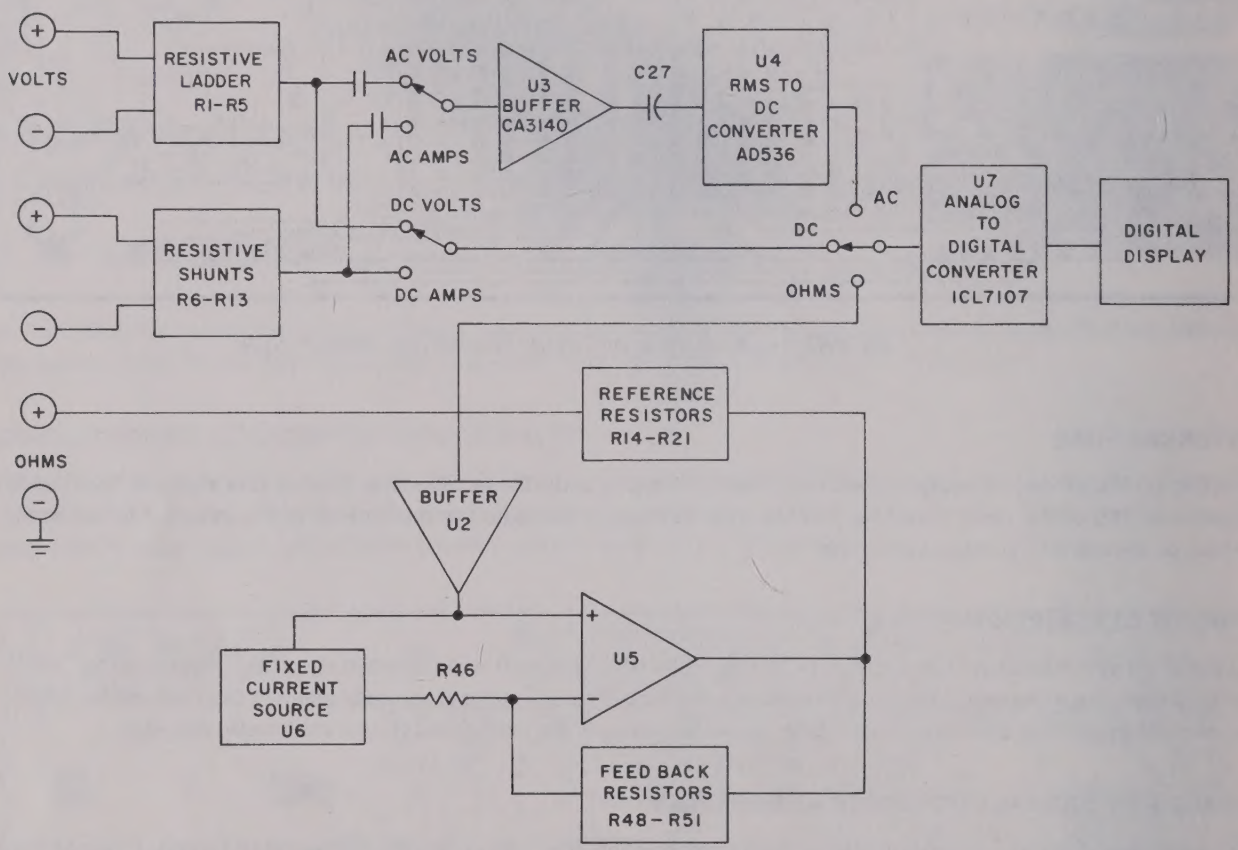

FIGURE 2, Simplified Functional Diagram of Digital Multimeter

MEASURING AC VOLTAGE AND CURRENT

For AC voltage measurements the voltage goes from the Resistive Ladder, through the Function Selector S5, into the Buffer Amplifier (U3), then through the RMS-to-DC Converter, and into the Analog-to-Digital Converter.

The Resistive Ladder contains frequency-compensating capacitors. This makes it possible to measure AC voltage at various frequencies.

The Buffer Amplifier is a high input impedance amplified. It prevents loading of the circuit being measured and is connected as a voltage follower.

The converter used in this section of the Digital Multimeter is a True RMS-to-DC Converter. This converter is the

heart of the converter circuit, shown in Figure 3. The converter (U4) takes the true root-mean-square level of an AC input signal and gives it an equivalent DC output level. Capacitor C7 determines the averaging time constant.

Capacitor C8 is a filter used to remove any ripple that may be present on the DC output of the converter. The network, consists of potentiometer R40 and resistors R41 and R42, trims the DC offset of convert AD536.

AC current measurements use almost the same circuitry as the AV voltage measurement except the voltage is developed across the Resistive Stunts R6 - R13.

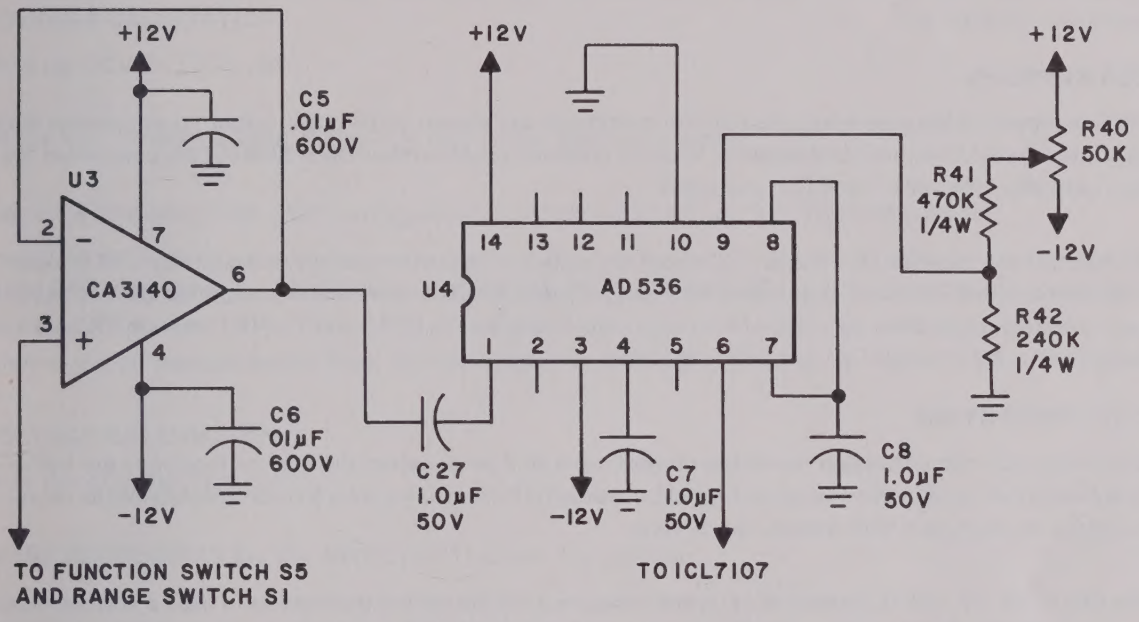

FIGURE 3, Schematic of the True RMS-to-DC Converter

MEASURING RESISTANCE

The resistance measuring section of the Digital Multimeter uses the lower set of input terminals shown in Figure 2. These are the same terminals used for measuring voltage in the upper portion of the figure. The red Voltage/ Resistance Input Terminal also connects to the input of U2. (Refer to the schematic diagram.) Press switch S7 in for the Ohms range. Press S8 in for the Lo OHMS range. The circuit runs from the red input terminal, through S7 or S8, to the input of the analog-to-Digital Converter (U7).

The multimeter measures resistance by providing a constant current through the unknown resistance and measure the voltage developed.

The constant current circuitry consists of the Buffer Amplifier (U2), Fixed Current Reference CA3086 (U6), OP amp (U5), Feedback Resistors, and the Reference Resistors (R14 - 16). The Buffer Amplifier is a high impedance amplifier which prevents the loading of the unknown resistance.

The Operational Amplifier senses the voltage at the output of the buffer amplifier and the fixed current reference and then compares them. The op amp outputs a correcting voltage when voltages differ. The correcting voltage is fed back to the negative input by the feedback resistors. This produces a balance at the inputs of the op amp.

The input to the Buffer Amplifier is equal to positive and negative inputs of the op amp when the inputs of the op amp are balanced.

The fixed current reference senses the voltage at the output of U2. The voltage is now equal to the voltage at the negative input of U5. The fixed current reference then compensates for the change in voltage at the negative input of U5, by placing a proper voltage at its output. By keeping the voltage across R46 constant, it keeps the current through R46 constant, which is the same current through the feedback resistor.

The feedback resistors are different for OHMS and LO OHMS. The feedback resistance is ten times greater for OHMS than LO OHMS. Therefore, the op amp's output is ten times greater for OHMS than it is for LO OHMS. The voltage across the reference resistors will be kept constant in all ranges if the inputs of the op amp are balanced and the current through the feedback resistors is kept constant. The Reference Resistors determine the current through the unknown resistances.

POWER SUPPLIES

The AC line input and the power supplies for the multimeter are shown at the upper left of the schematic diagram. The line input fuse (F1) is rated at ¼ ampere. The unit is turned on when the Power Switch (S9) completes the connection between terminals 7 and 8 at the input.

The bridge rectifier supplies Ω12 V and - 12 V from separate sections of the supply using diodes CR6 through CR9. Most of the multimeter circuitry is powered by these voltages. The full-wave rectifier supplies Ω5 V to the Display Indicator and to several other sections of the multimeter using diodes CR10 and 11. VR1 through VR3 are voltage regulation units. C9 through C14 are filter capacitors.

CIRCUIT PROTECTION

A 2-amp magnetic circuit breaker limits the current input to 2 amps when the current functions are being used. CR15 prevents the input to the Analog-to Digital Converter (U7) from rising over 5 volts. The Analog-to-Digital Converter would be damaged with inputs over 5 volts.

Diodes CR17, 26, 27 and 18 protect the current measuring section of the multimeter in case a voltage is applied across the Current Input Terminals. CR17 and 26 would conduct for one polarity of voltage, CR18 and 27 for the other. This protects the unit from voltage of either polarity.

The line input fuse protects the entire unit. In addition, there are other protective devices built into the unit. A 0.4 amp magnetic circuit breaker protects the high voltage input for the OHMS and LO OHMS functions. CR12 through C14 and CR21 through CR25 provide additional protection.

CALIBRATION PROCEDURE

The Energy Concepts Digital Multimeter was calibrated at the factory and should not require additional calibration. Follow this procedure if it requires calibration: The accuracy of the unit will depend on the accuracies of the resistance, current, and voltage sources used. Only known accurate values should be used.

PRELIMINARY CALIBRATION

1. Plug the unit into an Ac outlet after it has been removed from the case.

2. Press the POWER BUTTON (S9) to turn it on.

3. Connect the voltage jacks of a previously calibrated 3½-digit DMM to the GND. and 1.0 V ADJ. test points of the meter to be calibrated. These are identified on the PC board.

4. Press the OHMS BUTTON (S7).

5. Adjust R61 for a reading of 1.000 VDC on the calibrated meter.

6. Press the DCV BUTTON (S3).

7. Adjust R60 for a reading of 100.0 mVDC on the calibrated meter.

8. Repeat Steps 4 through 7 until no further adjustments are required.

9. Remove the DMM leads from the tet points.

DC VOLTAGE CALIBRATION

1. Press the DCV BUTTON (S3).

2. Set the VOLTS/OHMS RANGE SWITCH (S1) to the 200 mV position.

3. Connect a calibrated 100 mVDC voltage source to the red and black VOLTS/OHMS JACKS.

4. Adjust R60 for a reading of 100 mV on the DIGITAL DISPLAY, or - 100 mV if the input polarity is reversed.

5. Remove the DC voltage source from the input jacks.

AC VOLTAGE CALIBRATION

1. Press the ACV BUTTON (S5).

2. Set the VOLTS/OHMS RANGE SWITCH (S1) to the 2 V position.

3. Connect a calibrated 1 V, 400 Hz AC voltage source to the red and black VOLTS/OHMS JACKS.

4. Adjust R40 for a reading of 1.000 ± .002 on the DIGITAL DISPLAY.

5. Remove the AC voltage source from the input jacks.

RESISTANCE CALIBRATION - 10K RANGE

1. Press the LO OHMS BUTTON (S8).

2. Set the VOLTS/OHMS RANGE SWITCH (S1) to the 20 KΩ position.

3. Connect an accurate resistance value of 10 KΩ to the red and black VOLTS/OHMS JACKS.

4. Adjust R48 for a reading of 10.00 ±0.01 on the DIGITAL DISPLAY.

5. Press the OHMS BUTTON (S7).

6. Adjust R50 for a reading of 10.00 ±0.01 on the DIGITAL DISPLAY.

7. Disconnect the 10 KΩ resistance from the input jacks.

RESISTANCE CALIBRATION -1K RANGE

1. Press the OHMS BUTTON (S7).

2. Set the VOLTS/OHMS RANGE SWITCH (S1) to the 2 KΩ position.

3. Set the VOLTS/OHMS RANGE SWITCH (S1) to the 2 KΩ to the red and black VOLTS/OHMS JACKS.

4. Adjust R17 for a reading of 1.000 ±0.001 on the DIGITAL DISPLAY.

5. Disconnect the 1 KΩ resistance from the input jacks.

RESISTANCE CALIBRATION - 100 Ω RANGE

1. Press the LO OHMS BUTTON (S8).

2. Set the VOLTS/OHMS RANGE SWITCH (S1) to the 200 Ω position.

3. Connect an accurate resistance value of 100 Ω to the red and black VOLTS/OHMS JACKS.

4. Adjust R15 for a reading of 100.0 ±0.1 on the DIGITAL DISPLAY.

5. Disconnect the 100 Ω resistance from the input jacks.

DC CURRENT CALIBRATION

1. Press the DCA BUTTON (S4).

2. Set the CURRENT RANGE SWITCH (S2) to the 2A position.

3. Connect an accurate 1 ADC current source to the red and black CURRENT JACKS.

4. Adjust R13 for a reading of +1.000 ±0.001 on the DIGITAL DISPLAY, or −1.000 ±0.001 if the input polarity is reversed.

5. Remove the current source from the input jacks.

SERVICE PARTS LIST

P.C. BOARD PARTS

SCHEMATIC REFERENCE NUMBER	PART NUMBER	COMPONENT DESCRIPTION
		TRANSISTORS AND ICs
U1	50232	CD4016,Quad Analog Switch
U2, 3	50313	CA31405, Op Amp
U4	50229	AD536AJD, True RMS-DC Converter
U5	21508	741, Op-Amp
U6	21614	CA3086, Transistor Array
U7	50234	ICL7107, 3½-Digit A-D Converter
VR1	50235	LM341P12, +12V Regulator
VR2	50236	MA79M12, −12V Regulator
VR3	20821	MC7805, 5V Regulator
VR4	NOT USED	
VR6	50231	LM336Z, 2.5V Reference
		DIODES
VR5	50272	IN4738A, 8.2V Zener
CR1, 4, 5	NOT USED	
CR6-14, 2I-25	20108	1N4002, Diode
CR15	50286	10101, Diode
CR16	NOT USED	
CR17, 18, 26, 27	20428	MR754, Diode
CR19	21035	1N4148, Diode
CR20	NOT USED	
		CAPACITORS
C1, 4 5, 6, 14	15130	.01 μF, 600V
C2	NOT USED	
C3	50239	10μF, 35V, Tantalum
C7, 8, 10, 12	20911	1 μF, 50V
C9, 11	39021	100 μF, 50V
C13	32120	500 μF, 15V
C15	40514	100 pF, 125V
C16, 19	50230	0.22 μF, 100V, Mylar
C17	50265	0.1 μF, 100V, Mylar
C18	50266	0.47 μF, 100V, Mylar
C20-24	NOT USED	
C25	50283	1000pF, Mica
C26	40517	.015 μF, Mylar
C27	50242	1.0 μF, 50V, Mylar
C28	NOT USED	
C29	50282	510 pF, Mica

P.C. BOARD PARTS

SCHEMATIC REFERENCE NUMBER	PART NUMBER	COMPONENT DESCRIPTION
		POTENTIOMETERS
R13	50241	10 OHM, Multiturn Trimpot
R15, 17, 48, 50, 60	50240	100 Ohm, Multiturn Trimpot
R40	50279	50K, Cermet Trimpot
R61	50278	10K, Multiturn Trimpot
		RESISTORS
R1	50244	9M,¼W, 0.25%
R2	50245	900K, ¼W., 0.25%
R3	50246	90K, ¼W., 0.25%
R4, 6	50247	9K, ¼W., 0.25%
R5	50248	1K, ¼W., 0.25%
R7	50249	900, ½W., 0.5%
R8	50250	90, ½W., 0.5%
R9	50252	9, ½W., 0.5%
R10	50252	.9, 5W., 0.5%
R11	50253	.1, 5W., 1%
R12, 14	50258	60, ¼W., 0.5%
R16	38637	820, ½W., 5%
R18	50257	9.1K, ¼W., 0.5%
R19	50256	91K, ¼W., 0.5%
R20	50255	910K, ¼W., 0.5%
R21	50254	9.1M, ¼W., 0.5%
R22, 23, 25-35	NOT USED	
R24, 43, 66	20657	470, ¼W., 5%
R36	541-05103	10K, 1W., 5%
R37-39	NOT USED	
R41	22944	470K, ¼W., 5%
R42	50274	240, ¼W., 5%
R44, 46, 48	50273	10K, ¼W., 5%
R45	50275	47K, ¼W., 5%
R47, 56	20658	100K, ¼W., 5%
R49	50277	30, ¼W., 0.5%
R51	50276	1.05K, ¼W., 0.5%
R52	19055	100K, ½W., 1%
R53, 54	NOT USED	
R55, 67	34212	470K, ½W., 1%
R57	20648	56K, ¼W., 5%
R58, 59	5026I	24K, ¼W., 0.5%
R62	22229	500, ¼W., 0.5%
R63	50260	10K, ¼W., 0.5%
R64	20659	2.2K, ¼W., 5%
R65	20651	1.2K, ¼W., 5%
R69	50259	1.1M, ¼W., 0.5%

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P.C. BOARD PARTS

SCHEMATIC REFERENCE NUMBER	PART NUMBER	COMPONENT DESCRIPTION
		MISCELLANEOUS
T1	50221A	Transformer
S1	50224	Rotary Switch, Volts/Ohms
S2	50223	Rotary Switch, Amps
S3-9	50222	Pushbutton Switch Assembly
F1	21539	Fuse, ¼ Amp
J1	50264	Socket, 40-Pin
	40058	Socket, 8-Pin
	40027	Socket, 14-Pin
	22025	Fuse Clips
	29020	Line Cord
	22355	Line Cord Clamp
	50270B	P.C. Board
	16237	Rubber Feet
	40513	Dogbone Spacers
		HARDWARE
	10823	Screw, 6/32 in. x 3/8 in.
	1190	Nut, Hex 6-32
	967	Washer
	709	Mtg. Screws, 6/32 in. x ¼ in.
	735	Washers
		DISPLAY BOARD PARTS
DS1	50238	2-Segment Display
DS2-4	50237	7-Segment Display
R70, 71	20654	270, ¼W., 5%
P1	50228	40-Pin Ribbon Cable Plug
	50271	P.C. Board
		ASSEMBLY PARTS
CB1	50227	Circuit Breaker, 2.0 Amp
CB2	50226	Circuit Breaker, 0.4 Amp
CR2, 3	22970	Flashing LED, FRL 4403
J2, 4	30523	Input Jack, Red w/Nut
J3, 5	30524	Input Jack, Black w/Nut
	50268B	Front Panel
	30079	Knob, Grey
	40510	Pushbutton, Blue
	40511	Pushbutton, Red
	50225	Bezel Assembly w/Hardware
	50269	Fiber Spacer
	19017	Shrink Tubing
	4200	Mounting Nut
	50284	15 in. 2 Conductor Shield Cable
	20721	Wire Ties

SCHEMATIC REFERENCE NUMBER	PART NUMBER	COMPONENT DESCRIPTION
	29184	Grounding Lugs
	20583	Washer No. 8 7/16 in. O.D.
	50292	Shoulder Washer
	20843	1461 Shielded Cable

WARRANTY

ENERGY CONCEPTS, INCORPORATED, warrants this equipment to be free from defective material and workmanship and agrees to remedy any such defect or to furnish a new part in exchange for any part of this unit which under normal installation, use, and service discloses such defect, provided that the unit is delivered by the purchaser to the leader from whom purchased, or to Energy Concepts, Incorporated, or to a stipulated agent, intact, for the purpose of examination within a period of two years from the date of sale to the original purchaser and provided such examination discloses in our judgment that it is defective.

This warranty does not apply if the equipment has been subjected to misuse, neglect, improper installation, used in violation of instructions provided by us, or if repaired or in any way altered outside of our factory or authorized service facility, or if the serial number has been removed, defaced or changed.

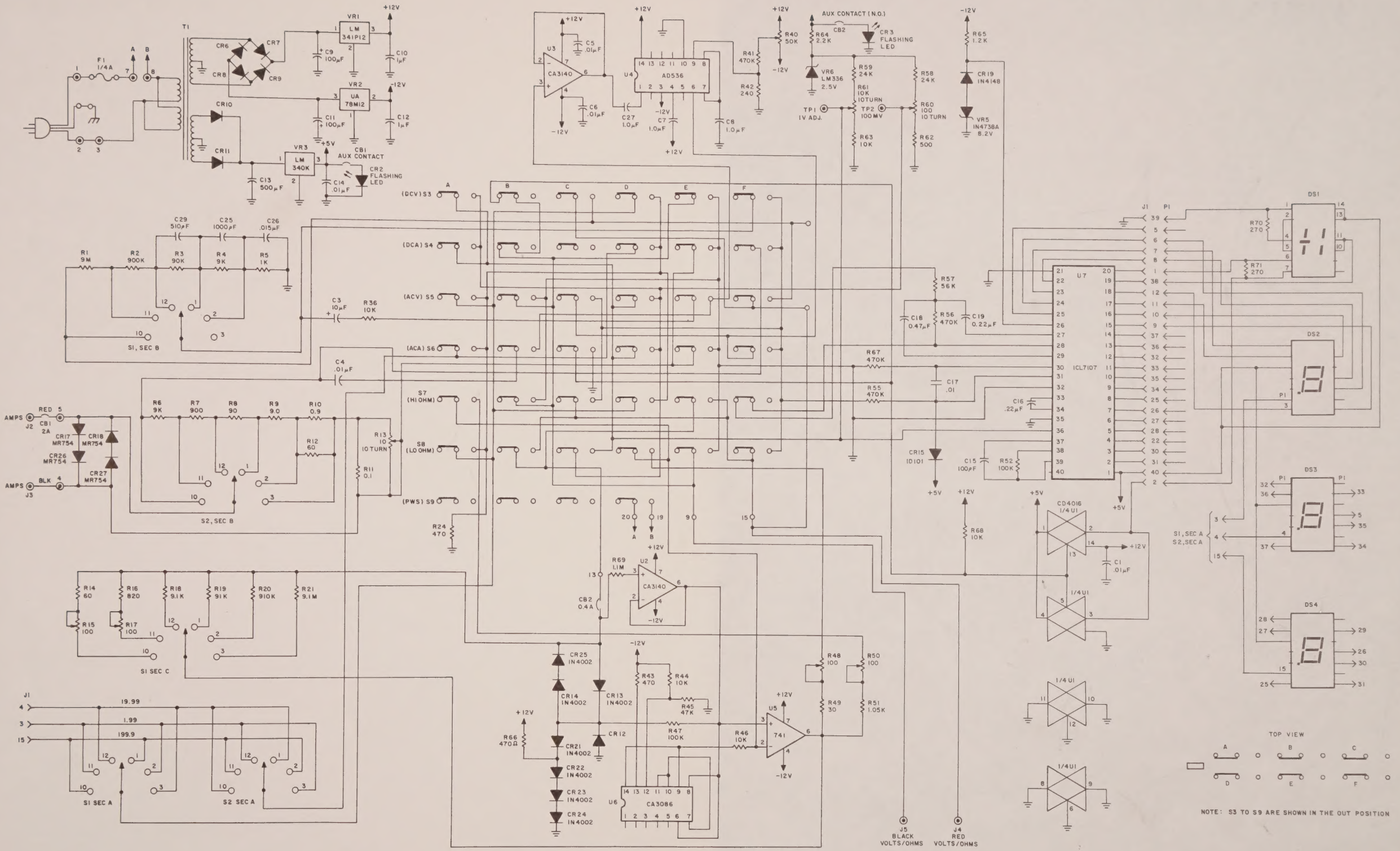
Any part approved for remedy or exchange hereunder will be remedied or exchanged without charge to the owner.

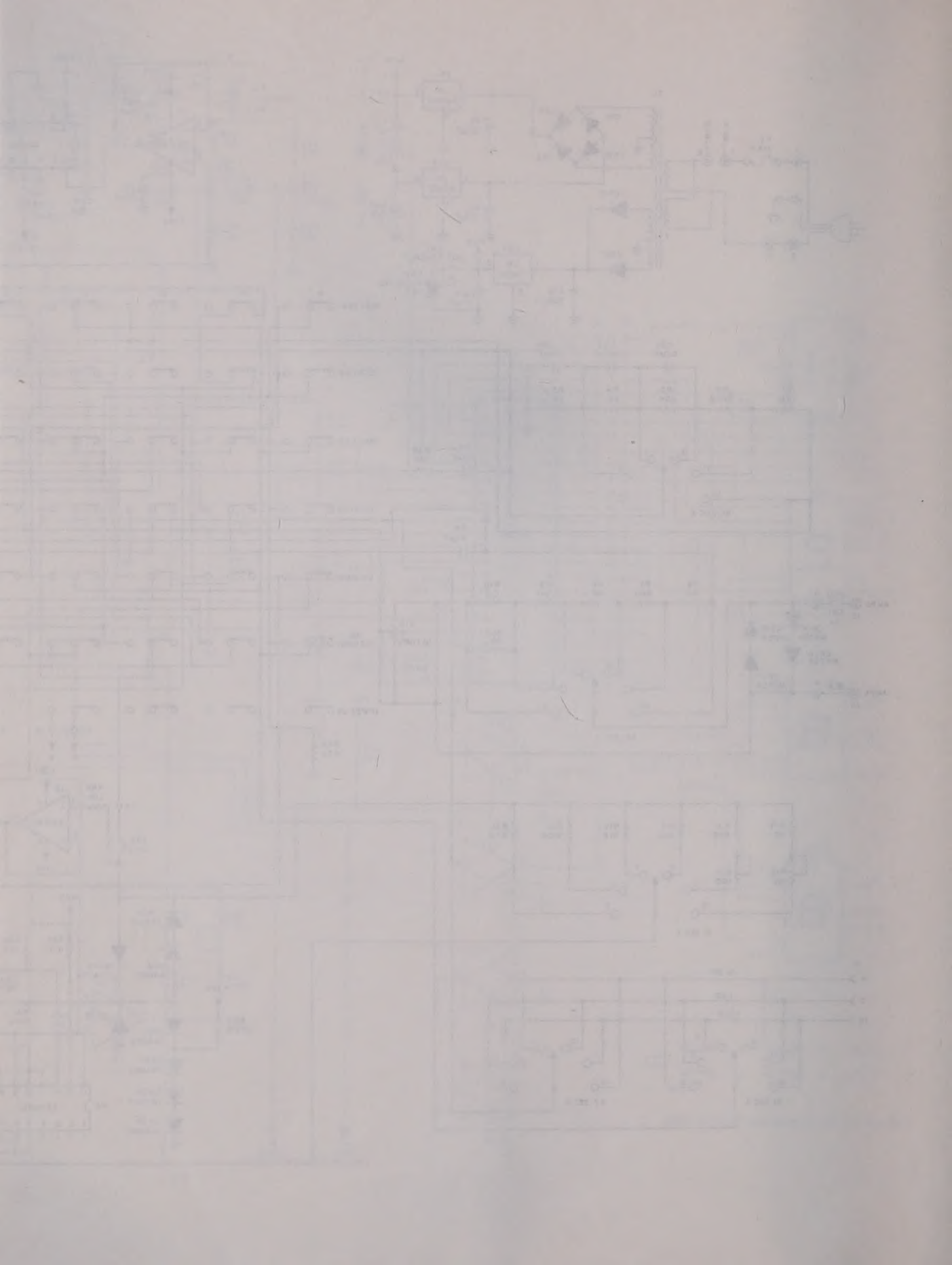
Energy Concepts, Inc., assumes no liability for injury, damage, or expense claimed to have been incurred through the use or in the installation of our equipment and products.

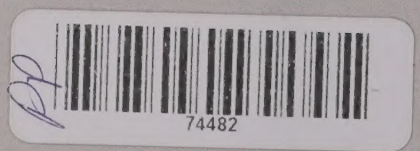
This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of this equipment.

Further information can be obtained from:

Energy Concepts, Inc.
3254 N. Kilbourn Ave.
Chicago, Illinois 60641


T1
F1 1/4A
CR6
CR7
CR8
CR9
CR10
CR11
VR1 LM 341P12
VR2 UA 78M12
VR3 LM 340K
C9 100µF
C10 1µF
C11 100µF
C12 1µF
C13 500µF
C14 .01µF
+12V
-12V
+5V
CB1 AUX CONTACT
CR2 FLASHING LED
U3 CA3140
U4 AD536
C5 .01µF
C6 .01µF
C27 1.0µF
C7 1.0µF
C8 1.0µF
R40 50K
R41 470K
R42 240
AUX CONTACT (N.O.)
CB2
CR3 FLASHING LED
R64 2.2K
VR6 LM336 2.5V
R59 24K
R61 10K 10TURN
R58 24K
R60 100 10 TURN
R63 10K
R62 500
TP1 1V ADJ.
TP2 100MV
R65 1.2K
CR19 IN4148
VR5 IN4738A 8.2V
(DCV) S3
(DCA) S4
(ACV) S5
(ACA) S6
S7 (HI OHM)
S8 (LO OHM)
(PWS) S9
R1 9M
R2 900K
R3 90K
R4 9K
R5 1K
C29 510µF
C25 1000µF
C26 .015µF
S1, SEC B
C3 10µF
R36 10K
C4 .01µF
R6 9K
R7 900
R8 90
R9 9.0
R10 0.9
R12 60
R13 10 10TURN
R11 0.1
S2, SEC B
AMPS J2
AMPS J3
RED 5
BLK 4
CB1 2A
CR17 MR754
CR18 MR754
CR26 MR754
CR27 MR754
R24 470
R14 60
R16 820
R18 9.1K
R19 91K
R20 910K
R21 9.1M
R15 100
R17 100
S1 SEC C
J1
19.99
1.99
199.9
S1 SEC A
S2 SEC A
R69 1.1M
CB2 0.4A
CR25 IN4002
CR14 IN4002
CR13 IN4002
CR12
CR21 IN4002
CR22 IN4002
CR23 IN4002
CR24 IN4002
R43 470
R44 10K
R45 47K
R47 100K
R66 470Ω
R46 10K
U5 741
U6 CA3086
R48 100
R50 100
R49 30
R51 1.05K
R57 56K
R56 470K
C18 0.47µF
C19 0.22µF
R67 470K
R55 470K
C17 .01
C16 .22µF
CR15 ID101
C15 100µF
R52 100K
R68 10K
U7 ICL7107
J5 BLACK VOLTS/OHMS
J4 RED VOLTS/OHMS
CD4016 1/4 U1
C1 .01µF
J1
P1
DS1
DS2
DS3
DS4
R70 270
R71 270
S1, SEC A
S2, SEC A
TOP VIEW
NOTE: S3 TO S9 ARE SHOWN IN THE OUT POSITION





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